DISPOSAL INTO NEW MINED SPACE
BRINE CAVERN OPTION
A DISCUSSION PAPER

FOR: ONTARIO WASTE MANAGEMENT CORPORATION

BY: GARTNER LEE LIMITED

SEPTEMBER 1987

GLL 87579

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September 11, 1987 GLL 87579

Ontario Waste Management Corporation
2 Bloor Street West
11th Floor
Toronto, Ontario
M4W 3E2

Attention: Mr. D. Chollak
Environmental Planner

Dear Sirs:

Re: Issuance of Draft Reports

A DRAFT is a rough copy of a report. The intent in issuing it is to allow other knowledgeable people associated with the project an opportunity to review the style and content prior to final issuance.

Since the FINAL report may differ from the draft, we think it only prudent to collect all of the DRAFT reports prior to issuance of the FINAL report.

We would appreciate it if your would see that all copies of the DRAFT are returned to us and then we will issue our FINAL report.

We thank you in advance for your co-operation.

Yours very truly,

GARTNER LEE LIMITED

John F. Gartner, P.Eng.,
President.

JFG:jmh

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2 Bloor Street West
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Attention: Mr. D. Chollak
Environmental Planner

Re: Disposal into New Mined Space - Brine Cavern Option, OWMC #A6

A review of the above disposal option has been completed as per our letter of August 20, 1987. A discussion of our finding is provided in the attached text.

We trust that this meets with your present needs and we would be pleased to discuss any questions you might have.

Yours very truly,

GARTNER LEE LIMITED

R. E. J. Leech, B.Sc., M.Eng.Sc.
Senior Hydrogeologist
Principal

REJL:ks

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DISPOSAL INTO NEW MINED SPACE
BRINE CAVERN OPTION - A DISCUSSION PAPER

1.0 INTRODUCTION

1.1 BACKGROUND

The Ontario Waste Management Corporation (OWMC) has requested Gartner Lee Limited (GLL) to provide preliminary review of data on the "Brine Cavern Option" of waste disposal into new mined space. The major components of this review are:

- a brief literature review of brine well design and regulations governing brine wells in Ontario
- a review of current technology of brine well construction and brine cavern construction, and
- a general estimate of costs for construction of salt caverns in the B salt horizon of the Salina Formation (in southern Ontario); this will exclude infrastructure requirements and the disposal of cavern washing brines.

1.2 ASSUMPTIONS

Detailed specifications for the construction and operation of a brine cavern for waste disposal are not available for this review. The general assumptions made for the review of this potential disposal option are as follows:

- the B salt unit of the Salina Formation will be the host unit for the cavern(s) at a depth of 400 to 700 m from ground surface.
- the treated waste residue is assumed to be essentially inert inorganics mixed with a cement solidification agent and will be in a pumpable slurry or dry pelletized form, and

- the quantity of treated waste residue is 100,000 m^3/a (150,000 tonnes/a) in the initial stages of development; this may be increased to 200,000 m^3/a (300,000 tonnes/a) over a period of time.

1.3 ACKNOWLEDGEMENTS

A number of individuals from private industry and government agencies were contacted and provided useful information for the completion of this study. Their assistance is gratefully acknowledged.

2.0 BRINE CAVERNS

2.1 HISTORY AND USE IN SOUTHWESTERN ONTARIO

The production of salt from a brine well began near Goderich, Ontario in 1866 by the Goderich Petroleum Company. Several brine wells were in operation in the vicinity of Goderich by 1872 and by 1914 eleven companies across southwestern Ontario were producing salt from brine wells. Well depths varied from about 285 m at Kincardine to about 518 m at Mooretown. Brine wells were used as the principal method of salt extraction from the Salina Formation up until the 1950's when conventional underground mining began at Windsor and at Goderich. Early brine well operations consisted of individual wells. Later developments included brine well fields which consist of several closely spaced wells. Enlargement of the brine cavity in each well eventually causes a breakthrough to adjoining cavities creating hydraulic interconnection between wells. Once interconnection between wells is achieved, certain wells will serve as water injection wells and others will become brine production wells. Brine well fields are more effective in removing large volumes of salt and are therefore more commonly used than individual wells.

Some caverns created by individual brine wells were found to be suitable for the storage of liquid hydrocarbons. Refinements in the technology of brine operations eventually led to the development of brine cavern construction for the creation of underground storage space for liquid hydrocarbons. Dow Chemical Ltd. of Sarnia is a major commercial producer and supplier of brine cavern storage. Salt beds of the Salina Formation have proven to be unreactive toward hydrocarbons and are therefore ideal as a storage medium. Some of the oldest brine caverns in use today were constructed in the early 1950's.

As reported by Underground Resource Management Inc. and Gartner Lee Associates Ltd., 1984, there were 63 active liquid hydrocarbon storage caverns at Sarnia and three at Windsor in 1980. The caverns are all developed in the Salina Formations and range in size from 6,400 m^3 to 181,300 m^3. By the end of 1980 about 2,214,200 m^3 of brine cavern storage space had been created in southwestern Ontario. New brine caverns are produced each year through brine well operations for the production of salt. A number

of these caverns are being constructed for use as storage caverns after the salt has been extracted. Currently there are about 10 new brine caverns in the process of being created or enlarged for storage purposes in southwestern Ontario (Mr. T. Rogers, personal communication, 1987).

2.2 BRINE CAVERN CONSTRUCTION AND OPERATION

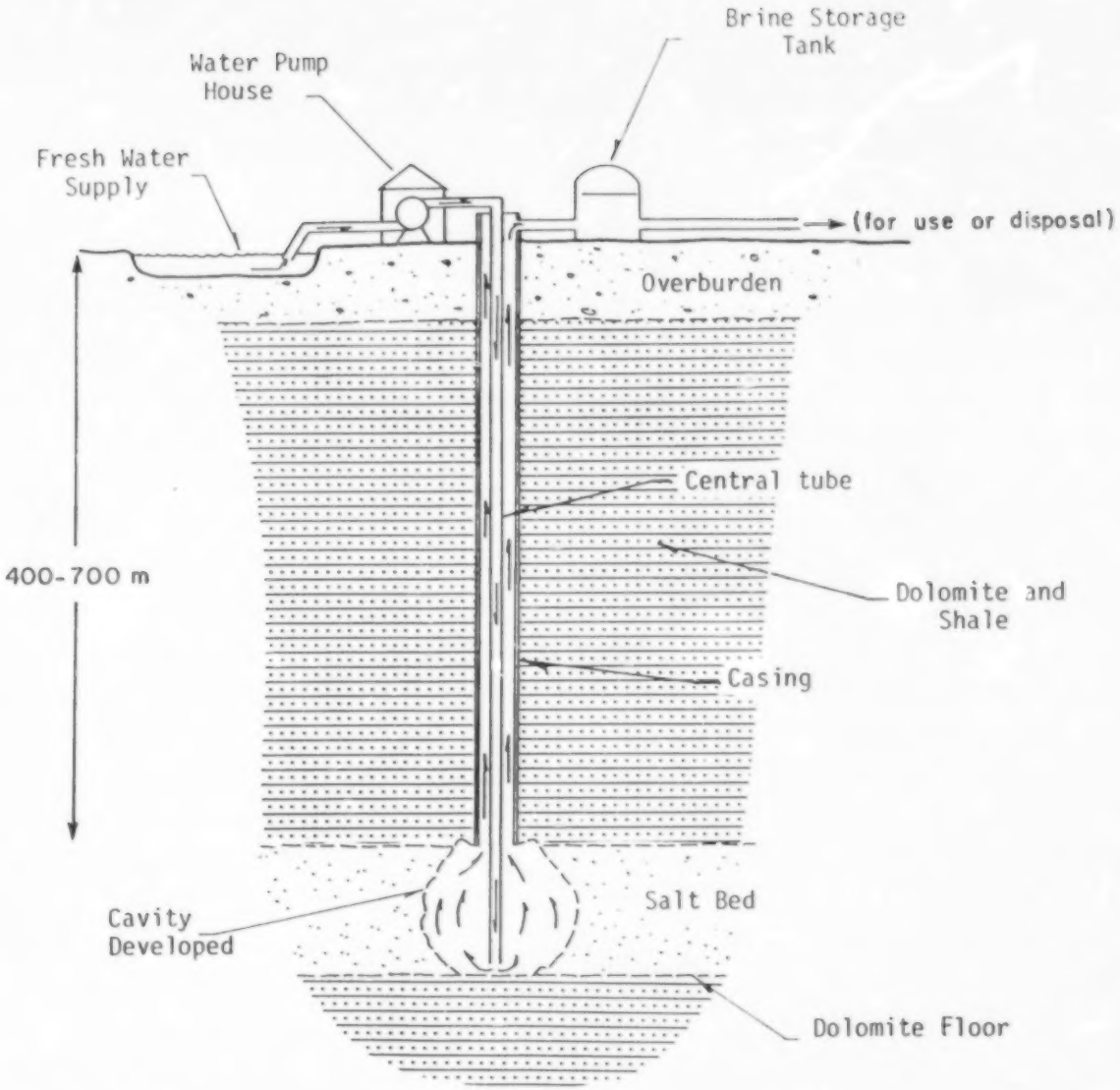
The first step in brine cavern construction is the selection of an appropriate site. Many of the existing brine caverns are located near or adjacent to chemical processing plants or refineries that use the salt brine produced from the cavern washing or provide the liquid hydrocarbons for storage in the caverns. Land access and mineral rights must be secured prior to the construction of a brine cavern. Creation of a brine cavern is accomplished by injecting fresh water into the salt bed and the removal of the resulting cavern washing brine.

A deep well is first constructed over the salt cavern site and permanent steel casing is cemented in place. The casing generally consists of two or three strings. A typical casing string consists of 51 mm diameter surface casing that extends into the bedrock, a 400 mm diameter intermediate casing extending through the Detroit River Group of Formations, and 270 mm diameter lower casing that extends to the salt unit. An open hole is drilled to the bottom of the salt cavity and a smaller diameter tubing is installed within the casing.

The tubing is used for the injection of water for development of the cavern. A typical brine well operation is shown on Figure 1. Different methods are available for brine cavern development. The most commonly used method involves the injection of fresh water through the tubing which extends to the bottom of the salt cavity. As the fresh water returns to surface it dissolves the salt around the open hole. The resulting cavern washing brine is either used as a feed stock for certain chemicals such as chlorine gas or caustic soda or is disposed of as a waste material. In the latter case a suitable disposal method must be found. Disposal methods used in the past include waste disposal injection wells and removal of brine by large ships and disposal at sea. In general, salt caverns result in a volume of cavern washing brine about ten times the volume of the cavern itself.

Figure 1

BRINE WELL OPERATION



The size and shape of the cavern can be controlled through a variety of means. The shape of the cavern is monitored as it is constructed. Sonar logging is used to determine the size and shape of the cavern as it is constructed. This technology has been in use for many years and provides an accuracy of about ± 5% for assessment of cavern dimensions. Depending on its size, it may take from one to three years to complete a cavern by washing with fresh water.

Most storage caverns in salt in southwestern Ontario operate on the basis of displacing saturated brine within the completed cavern with the products to be stored. These caverns are always filled with either saturated brine, stored hydrocarbon products or a combination of both. Only one cavern in the Sarnia area operates on a "dry" basis where saturated brine was removed from the cavern prior to the storage of liquid petroleum gas. The "dry" storage cavern has developed over the past several years due to technical requirements of specialized stored products.

3.0 REGULATORY AUTHORITY

The Ministry of Natural Resource (MNR) has statutory control over the exploration and drilling for the production and storage of oil and gas through the "Petroleum Resources Act, 1971". The MNR's primary responsibility is to prevent waste of resources. Rules and regulations concerning the drilling, completion location and plugging of all types of wells except water supply wells have been developed by MNR. These rules are set out in Regulation 752 under the Petroleum Resources Act. A number of regulations are under review and new guidelines are being developed for the construction and operation of brine wells.

Existing brine caverns in southwestern Ontario are currently used for storage and not waste disposal and are regulated primarily by MNR under the Petroleum Resources Act. The MOE is involved in the permit approval process for the disposal of brine produced from the creation of caverns. These brines have often been disposed into underground formations by the use of brine injection wells. Permit applications for both brining and disposal wells are submitted to MNR which is responsible for permitting the wells to be drilled. The MOE is responsible for reviewing geologic data, engineering plans for surface facilities and operational controls before issuing a Certificate of Approval to use the well as a disposal facility. The Ministry of the Environment may request a public hearing to be held before the Environment Assessment Board.

The design and construction of brine caverns is generally the responsibility of the proponent of the facility. This is generally contracted to specialists in the field or is completed with inhouse expertise as is the case with some industries in southwestern Ontario.

4.0 BRINE CAVERN OPTION

"Wet" brine cavern storage in southwestern Ontario is a proven technology that has worked successfully since the 1950's. "Dry" brine cavern storage from brine wells involves newer technology and has occurred on a limited scale in southwestern Ontario for the past several years. A detailed assessment of brine caverns for the disposal of treated waste residue will require that a number of major issues be addressed. These are summarized in the following discussions.

4.1 TECHNICAL CONSIDERATIONS

- A suitable geologic environment must be identified through a site selection process that would identify suitable candidate areas; areas of increased salt thickness and depth of salt from surface offer the greatest potential isolation of wastes.

- Detailed hydrogeologic and geotechnical studies are required to assess site suitability; additional factors such as transportation, socioeconomic impact and economics must be addressed.

- Chemical compatibility testing will be required between the treated waste residue and the salt formation.

- The optimum size and configuration of a salt storage cavern is dependant upon site specific geologic and geotechnical conditions and the volume of treated residue to be disposed.

- A brine cavern disposal facility will likely require the use of multiple brining wells in order to create a controlled cavern large enough to accept the predicted volumes of waste.

- The most common practice for disposal of treated residues would be to emplace them in a brine filled cavern. However, if the treated residue and the brine "reacted", then the resulting displaced brine may be considered a hazardous

waste and not acceptable for disposal by injection wells. This aspect would have to be addressed during the compatibility testing. This could also be resolved by the use of a "dry" brine cavern which is currently considered to be a relatively new technology.

- The construction of a brine cavern may take from one to three years to construct, depending on the size of the cavern.

4.2 OPERATIONAL CONSIDERATIONS

- The construction of a brine cavern disposal facility will require a well or wells to be completed into the disposal unit. Each well will require associated surface facilities for solution mining of the cavern and disposal facilities for the resulting cavern washing brine. Brine disposal may require the completion of disposal wells.

- The feasibility of injecting the treated waste residue through a relatively narrow diameter injection pipe or tubing must be investigated in order to determine the appropriate diameter of the well or wells through which the waste is injected into the disposal unit.

- A monitoring program must be developed to ensure long term containment of the treated waste residue in the brine cavern.

- Leachability testing of the treated waste residue with the cavern washing brine must be completed in order to determine the most appropriate method of cavern operation i.e. "wet" or "dry" disposal.

4.3 REGULATORY CONSIDERATIONS

- A proposed waste disposal facility utilizing salt caverns will likely require a detailed Environmental Impact Assessment and will need to satisfy MNR and MOE regulations and guidelines regarding well construction and waste disposal aspects of the proposed facility.

- Waste disposal in brine caverns is not an established practice in southwestern Ontario and any such proposal may cause new guidelines and/or regulations to be established by MNR and MOE.

- Current regulations and controls over brine cavern storage facilities for liquid petroleum products are jointly administered by MNR and MOE.

- Current regulations and controls over brine cavern storage facilities focus on the well construction aspects of the facilities. The actual design and construction of the storage caverns is largely the responsibility of the owners of the facility. Monitoring of cavern storage facility is often limited to monitoring of well head pressures and the maintenance of product storage records. Additional monitoring requirements may be instituted if leakage has been detected or if surface spills occur.

- New regulations and guidelines for the construction and operation of salt caverns for storage purposes are currently being developed by MNR.

4.4 ESTIMATED COSTS

Overall facility costs cannot be estimated without more specific information on the actual design of the proposed disposal facility. A number of assumptions have been made and the major cost components have been identified in the following outline.

Cost Assumptions

The following assumptions have a direct bearing on costs and would have to be confirmed with detailed studies to substantiate the general cost estimates.

i) Multiple brine caverns will be required to accommodate the treated waste residue.

ii) One 270 mm diameter well will handle 150,000 m^3 of treated waste residue.

iii) Cavern washing brines will be disposed of in the Detroit River Group of Formations above the brine caverns via two brine disposal wells.

iv) The life of the disposal facility is 25 years.

v) Brine caverns will be developed in the B salt unit of the Salina Formation.

vi) A land area of about 200 ha will be required for 25 years of disposal; land requirement for surface treatment facilities, administration facilities, lagoons and other related facilities can probably be accommodated within this area

The major cost components of a brine cavern disposal facility are outlined in Table 1. Estimated costs have been assigned to those components that could be quantified sufficiently at this stage using the above cost assumptions. Several major cost components will require more detailed studies in order to assess estimated costs.

TABLE 1 BRINE CAVERN OPTION - SUMMARY OF ESTIMATED COSTS

A)	Environmental Studies (Physical Setting, Geology, Salt Properties, Geologic Resources, Hydrogeology, Monitoring):		
	Stage 1 (site selection)	$	300,000
	Stage 2 (site specific studies)	$	3,500,000
B)	Initial Capital Costs:		
	1) Land and mineral rights (200 ha)		
	2) Construction of two brine disposal wells	$	700,000
	3) Surface Infrastructure (buildings, offices, etc.)		
	4) Lagoon(s) for temporary storage of brine washings		
	5) Monitoring well construction		
	6) Land Servicing costs		
C)	Annual Construction Costs for Brine Wells		
	1) Well construction costs per well	$	750,000
	2) Engineering fees	$	75,000
	3) Well Logging Services	$	50,000
	4) Cavern washing costs (mechanical and utilities)		
D)	Operating Costs:		
	1) Monitoring		
	2) Salaries for staff		
	3) Maintenance		
	4) Utility services		
	5) Brine well sealing		

5.0 CONCLUSIONS

- The use of brine caverns created from brine wells in southwestern Ontario has been limited primarily for the storage of liquid petroleum gas products. Limited use of salt caverns has been made for the storage of other chemical products including chlorinated hydrocarbons.

- Brine cavern storage of hydrocarbons has been commonly used in southwestern Ontario since the 1950's and is a proven technology.

- Estimated costs for creation of a brine cavern is about 1 million dollars per cavern. This estimate is subject to validation of the assumptions outlined in this report.

- Estimated costs for related site selection and site specific environmental studies are about 4 million dollars.

- Additional costs for land, infrastructure, operating, maintenance and monitoring will also be incurred. These require detailed study to assess estimated costs.

- The use of brine caverns for waste disposal will set environmental precedents in Ontario as this practice is not generally used.

- The construction and use of brine storage caverns are regulated jointly by MNR and MOE. New regulations and guidelines are currently in their development stages.

- Further consideration of the disposal of treated waste residue using brine caverns created by solution mining will require a variety of feasibility studies to more accurately define the anticipated costs and ultimate viability of this method of waste disposal.